in the Hohen Tauern that were still exploited in the Middle Ages. But at the middle of the sixteenth century all the workings were covered by a glacier. In 1570 the sheet of ice had a depth of 25 meters, which increased to 100 meters during the eighteenth century and then decreased. About 1880 the depth was only 40 meters and later during periods of retreat it has come to pass that the débris of wrecked buildings have reappeared after having been interred in the ice almost 400 years.

According to the record of the church at Grindelwald there was an almost uninterrupted series from 1539 to 1563, of winters with very little snow and often very warm summers. From 1565 to 1580, on the other hand, there was a period of very snowy winters. Thus in the middle of the century or about 1540 there commenced a period of extreme regression, during which the lower glacier of the Grindelwald did not pass the upper rocks (die obern Flühe), while from 1565 on the névés have been increasing. In 1580 the glacier began to pass beyond the rocks and to descend into the gorge; in 1584 the chapel of Sainte-Pétronelle was overturned,[24] and in 1588 a barn was destroyed; in 1593 the glacier reached to the village, invaded two chalets and a large number of barns, and shifted the bed of the Black Lütschine and of the Bergelbach. A road between Oberwallis and Grindelwald was buried beneath the ice. During the great retreat of the glaciers from 1860–1880 portions of this road were seen to reappear.[25]

According to Heim *it is not possible to say whether we are approaching a new glacial period or whether we have to do with a long secular variation in the glacier movements.*

THE REMAINS OF ANCIENT FORESTS IN SWEDEN.

Some botanists have maintained that Sweden's climate has grown colder because to-day forests occur only on the Scandinavian Alps while one finds the evident remains of forests that have been destroyed. In fact the researches in Swedish Lapland along the eastern slopes of the Scandinavian Alps, and particularly those by Gavelin,[26] have proved that rather recent remains of dead trees are to be found almost everywhere above the upper limit of the conifers. *It is particularly the pines* (*Pinus sylvestris*) *that have perished;* the remains of the spruce (*Pinus abies*) or of the birches are rather rare.

But observations have also shown that forests often spring up again. The truth probably is that the forests along their limit of vegetation, increase during a certain number of years, following which another series of years with excessive cold kills them off. Then after a new series of years with mild winters they again begin to grow up.

But higher up in the region of birches and even above it we find in the swamps and bogs quantities of subfossil pine probably dating from the "Atlantic and subboreal period" of Sernander during which the temperature was so high that hazel nuts matured in Lapland. From this time also probably date the oaks buried in the sandy shores of the Clara River in Vermland which one often finds there buried at a depth of 2 to 4 meters beneath the surface of the soil in localities much farther north than the present limit of the oak.

We will not here go into further details concerning these interesting questions to which a final answer has not yet been found.

[24] According to an unverified tradition the bell dated from 1044 A. D.

[25] For further details see *Heim*, op. cit., p. 512–516.

[26] *Gavelin, Axel.* Trädgränsförskjutningarna inom Kamajokks vattenområde (Lilla Lule älf.). Sveriges Geologiska Undersökning, Årsbok, 1909, 3, no. 10.

CONCLUSION.

Our researches have led to the result that there exist everywhere climatic variations of long and short duration, but it is not possible to prove that the climate of Europe has changed for either better or worse during historic times.

P. S.—"As I am closing these researches [last signature was printed Dec. 14, 1915] I am in receipt of the interesting memoir by Prof. J. W. Gregory "Is the Earth Drying Up?"[27] which contains a criticism of the theories put forward by Prince Kropatkin and Prof. Ellsworth Huntington that our earth is steadily growing drier and drier. Gregory's researches have led him to the same result I have reached. "One fact," he says, "does seem to me to result clearly from the evidence; there have been many widespread climatic changes in late geologic times, while in historic times there has been no world-wide change of climate."

VIOLENT EASTERLY WINDS AT TATOOSH ISLAND, WASH.

By Ralph C. Mize, Observer.

[Dated: Weather Bureau, Tatoosh Island, Wash., Mar. 18, 1916.]

Wires and shrubbery on Tatoosh Island received a heavy coating of ice during the prevalence of a strong easterly breeze on the early morning of February 1, between easterly storms. The rigging of the radio station was covered with from ¼ to ¾ inch, varying with elevation from ground level to 250 feet above, and the aërial was torn away by the excessive weight of the ice. Thawing extended, during the day, to a height of approximately 75 feet, but the coating on the upper 175 feet was not appreciably diminished until it was cracked by the swaying of the cables, and torn loose by the unusual violence of the east-northeast storm of February 2. Flying fragments of ice made travel dangerous in the vicinity of the radio station and the Weather Bureau station throughout that day and night; and the fragments broke all the easterly windows in the Weather Bureau building. The barograph record shows false rises of 0.04 to 0.10 inch from 4:50 p. m. (when the office window broke) to about 7:30 p. m. when the window was boarded up (see fig. 1).

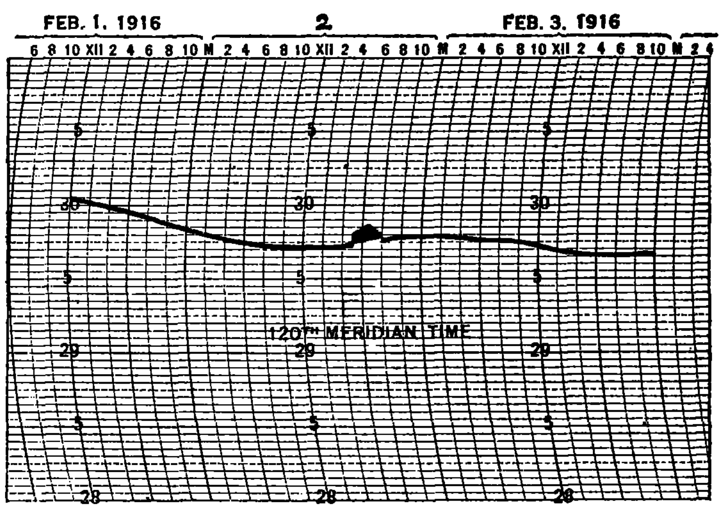

FIG. 1.—Barogram for Feb. 1-3, 1916, at Tatoosh Island, Wash., showing false rises on the 2d (4:50–7:30 p. m.), due to broken window.

[27] *Gregory, J. W.* In The Geographical Journal, London, 1914, 43: 293–318.

The average wind velocity for February 2 was 68.4 miles, the 5-minute maximum was 88, and the extreme for 1 minute was at the rate of 111 miles per hour. In maximum velocity alone, this storm is tied with the southerly storm of December 17, 1912, for second place and exceeded only by the storm of December 25, 1908. A thorough analysis would show this storm to be in an entirely different class from the other storms mentioned and show that much of the force of the easterly winds is confined to the immediate vicinity of the station. As a matter of fact there is too much difference in the characteristics of the easterly storms and those of the storms from south to northwest to allow of classifying the former according to registered velocity alone. In this discussion the southeast wind is not considered as a storm wind, but as the introduction of a south or southwest storm.

This storm in common with all east-northeast storms, increased slowly in violence, maintained its full strength for several hours and gradually diminished, showing characteristics of the monsoon type of wind rather than those of the cyclonic type. The total movement between 11 a. m. and noon of February 1 was 22 miles and the subsequent hourly runs and maxima are given in Table 1. The hourly maxima differed from the total hourly runs by from 2 to 13 miles with an average difference of 4. The average run from noon to 9 p. m. of February 2 was 79, or 9 miles below the maximum; and between 2 and 5 p. m. the average was 81, or 7 below the maximum.

This wind varied only about 10° in either direction from east-northeast, veering toward east while under 65 miles and backing toward northeast with an increase in velocity.

As an illustration of the different types of storm winds from the other directions, similar records of the storm of December 17, 1912, are given at the bottom of Table 1. Here the differences range from 5 to 24 miles, with an average difference of 14 miles, or 3½ times the difference shown in the easterly storm. This ratio is greater than usual, but the variation is constantly exhibited in the same direction. During this storm, with increased rapidity of fall in pressure, the wind shifted from southeast to south, and with a rise in pressure it shifted to the southwest, then diminished in force and shifted to west and northwest, following the ordinary cycle of changes in one of the two general types of storms setting in from the southeast.

Under the influence of an anticyclone, the easterly winds may blow out of the Strait of Juan de Fuca with high velocities for several days at a time, with unclouded skies and otherwise pleasant weather. Masters of sailing vessels gladly take advantage of such weather conditions when outbound, and have completed the run from Puget Sound to San Francisco in five days, or less than half the time of an ordinary smart run. Many vessels have passed out of the strait under full sail before winds of more than 60 miles from east-northeast without damage. On the other hand, one vessel, while inbound off Neah Bay, was partially dismasted in a southwest squall of 56 miles. In the latter case the increase in force was too sudden to permit sufficient shortening of sail. In this connection it would appear that the verifying velocity for this station should be greater for the northeast rather than for the southeast wind, as at present.

Much of the force of the easterly wind is apparently local and due to the configuration of the strait. The shoreline on the south side for 5 miles eastward extends almost due east and west. A study of the maxima in east-northeast winds almost invariably shows more of the northerly component in the direction about the times of their occurrence, suggesting that the increase in speed is induced by lateral compression. There is no means of determining if these winds are stronger between the station and the near-by cape, but the cape's effect in the strait can frequently be noted. During the time on February 2 when the wind was averaging 80 miles the wind's effect on the water and on four passing steam vessels was observed to be no greater, at distances of 1 mile and more from the station, than that exerted during registered velocities of from 65 to 70 miles an hour from the same direction. Three of the vessels, inbound, made fair time against the wind and apparently were retarded not more than 4 miles an hour.

An important difference between the easterly winds and westerly winds is their respective effect on the waves. The swell is normally propagated from west to east, or on-shore. Any westerly wind tends to heighten the waves. An easterly wind, on the contrary, beats the sea down until a velocity of about 70 miles is attained

TABLE 1.—*Hourly wind movements and maximum velocities at Tatoosh Island, Wash.*

Date.	A. M. 1	2	3	4	5	6	7	8	9	10	11	Noon.
1916.												
Feb. 1 Total movement												
Feb. 1 Maximum velocity												
Feb. 2 Total movement	56	58	58	53	52	59	59	62	64	66	74	63
Feb. 2 Maximum velocity	60	60	61	60	56	61	62	65	68	72	80	76
Feb. 3 Total movement	55	52	58	53	55	57	54	54	53	53	53	50
Feb. 3 Maximum velocity	60	58	61	56	59	60	58	58	56	56	57	54
1912.												
Dec. 17 Total movement												
Dec. 17 Maximum velocity												

Date.	P. M. 1	2	3	4	5	6	7	8	9	10	11	Midnight.
1916.												
Feb. 1 Total movement	(39	39	43	42)	43	(43	42)	49	50	52	53	56
Feb. 1 Maximum velocity					48			51	54	54	56	58
Feb. 2 Total movement	79	77	81	81	81	79	78	78	78	73	72	60
Feb. 2 Maximum velocity	84	86	88	85	84	84	82	82	79	76	78	69
Feb. 3 Total movement	47	43	(42)	46	44	(39)						
Feb. 3 Maximum velocity	49	48		50	50							
1912.												
Dec. 17 Total movement	(14	13	13	18	24)	36	55	64	69	58	47	(43)
Dec. 17 Maximum velocity						60	60	74	88	78	54	

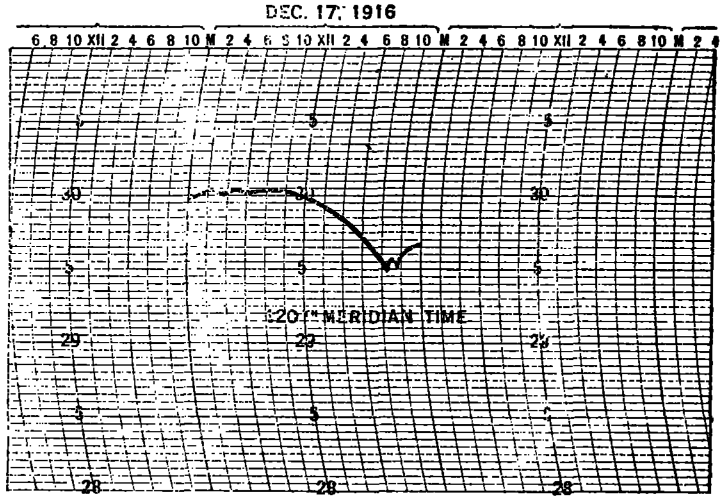

FIG. 2.—Barogram for Dec. 17, 1916, at Tatoosh Island, Wash., characteristic of storms other than easterly at that station.

after which the wind produces an off-shore wave of comparatively slight intensity.

The general character of the pressure changes in storms other than easterly is shown by the accompanying barograph trace for December 17, 1912 (fig. 2). Further study would be needed to determine the characteristic trace, if any, accompanying the easterlies.

A thorough study of storms of this locality would greatly increase the value of warnings by allowing them to be issued earlier and enabling the correct direction and force to be forecast more frequently. It is also probable that types of pressure changes as shown on the barograph records could be classified and reported by one word in such extent of detail as to be of great value to the forecaster at the district center.

WEATHER AS A BUSINESS RISK IN FARMING.[1]

By WILLIAM GARDNER REED and HOWARD R. TOLLEY.

[*Authors' abstract*, dated: Office of Farm Management, Washington, D. C., July 11, 1916.]

No type of agriculture can be successfully established in a region where the risk of loss by the occurrence of unfavorable weather conditions is not more than balanced by the profits at other times. It is necessary for the farmer's success as a business man to know the risk involved in raising particular crops. Climatic data as usually presented in averages and extremes give a general idea of the character of the region, but show nothing regarding the frequency of departures from the average conditions. The study of the occurrence of dates of last killing frost in Spring and first killing frost in Fall shows that it is possible to determine with a fair degree of accuracy the chance of killing frost after a given date in Spring or before a given date in Fall for places having records of 20 years or more. This possibility depends upon the demonstrable fact that the distribution of dates of last (or first) frost is that of the so-called normal frequency curve. A careful study of the frost records of 33 stations with a total of 823 observations shows the close relation between the normal frequency curve and the frequency polygon of the dates of last killing frost (see fig. 1). The properties of the normal frequency curve have been carefully investigated by Karl Pearson and others. From the results of this work it is possible to compute the percentage of occurrence of cases falling outside of any given date or to compute the date on which the percentage of cases falls to a given value. The characteristics of any phenomenon in which the distribution follows that of the normal frequency curve may be expressed by a single number known as the "standard deviation." When the standard deviation of the dates of last killing frost in Spring is known for any station the frost risk may be computed for any date by Table 1.

TABLE 1.—*Risk of killing frost in spring.*

Risk of occurrence.	Number of days after the average date.	Example, La Crosse, Wis.
Per cent.		
50	Average date	Apr. 26.
40	0.25×standard deviation	Apr. 26+(0.25×14.4)=Apr. 30.
30	0.52×standard deviation	Apr 26+(0.52×14.4)=May 4.
25	0.67×standard deviation	Apr. 26+(0.67×14.4)=May 6.
20	0.84×standard deviation	Apr. 26+(0.84×14.4)=May 9.
10	1.28×standard deviation	Apr. 26+(1.28×14.4)=May 15.

The autumn date when the risk of killing frost rises to a given per cent may be determined by subtracting from the average date the numbers obtained by the use of the standard deviation of the date of first killing frost.

The distribution of frost conditions in the United States is indicated by figures 2 and 3. Figure 2 shows the standard deviations of the dates of last killing frost in Spring. The isograms were drawn from the standard deviations determined for 569 stations fairly well distributed over the country. The lines are of necessity somewhat general. Figure 3 is a similar map of the standard deviations of first killing frost in autumn.

To compute the time available for plant growth in a given proportion of the years the most satisfactory method is that based on the risk at each end of the growing season. If the chance of safety on a given date in Spring is one-half and that on a given date in Fall is one-half, the chance of safety for the whole period between is one-half multiplied by one-half—that is, one-fourth. For many important crops about a four-fifths chance of safety is essential for continued success. A period in which the probability of no killing frost is four-fifths and of which the beginning is definitely known may be determined for any station as follows: Given the standard deviation of the date of last killing frost in spring, the date upon which the chance of killing frost falls to 10 per cent may be determined from Table 1. The date on which the chance of Fall killing frost rises above 10 per cent may be determined from the standard deviation of the dates of first killing frost in Fall and Table 1. Therefore, for any place the length of the available growing season (that is, number of days for which the chance is four in five), beginning at the date when the frost risk falls to 10 per cent, is the number of days between this date and the date on which the chance of fall frost rises to 10 per cent. Although this method of determining business risk is subject to limitations because of the shortness of the individual records, a careful examination of the records shows that in the large the computed dates on which the frost risk rises (or falls) to 10 per cent, when compared with the actual number of occurrences, is a very close agreement. From a total of 27,157 observations the lack of agreement between the computed and counted cases was but 17 in 10,000.

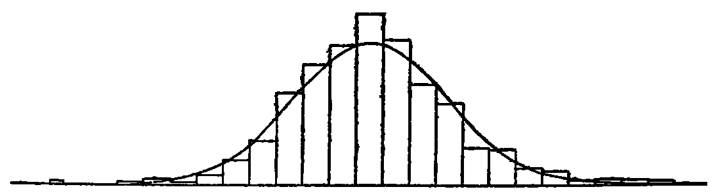

FIG. 1.—Frequency polygon and most probable normal frequency curve of the date of last killing frost in Spring for the combined records of 33 stations, comprising 823 observations.

Statements of risks based upon the results of such a study as this should not be regarded as seasonal forecasts. They simply represent, as far as may be determined from the data now available, the chances the farmer must meet if his business is to be permanently successful. The risks of loss which may profitably be carried varies with the crop and the economic conditions. For those crops in which the early production results in higher prices, e. g., garden vegetables, a considerable risk may be assumed with frequent losses and profit in the long run. In the case of other crops, e. g., corn, early production is of little or no advantage, and the risk which can be assumed is much smaller.

The occasional occurrence of unfavorable weather conditions is a risk which must be recognized by successful farmers. In the case of phenomena whose distribution follows the "normal law of frequency" this risk may be determined with a fair degree of accuracy. The method of determining the risk of frost occurrence has been described in this paper; the distributions of other phenomena seem to be more complicated, but further studies along this line will doubtless result in determining a method of computing the risks from their occurrence.

[1] *See* Geographical Review, New York, July, 1916, 2: 48-53.